"An Inquiry into the Nature of the Relationship between Sunspot Frequency and Terrestrial Magnetism." By C. CHREE, Sc.D., LL.D., F.R.S. Received February 8,—Read March 3, 1904.

(Abstract.)

§ 1. The formula

$$R = a+bS \quad \text{.............................} \quad (1),$$

where R is some magnetic quantity such as the amplitude of the diurnal oscillation of the needle, a and b constants, and S sunspot frequency (after Wolf and Wolfer), was first applied by Wolf to the mean declination range throughout the year.

In a recent paper,* mainly devoted to other subjects, I applied it to the ranges, and the sum of the 24 hourly differences from the mean for the day, in the mean monthly and annual diurnal inequalities of declination, inclination, horizontal force, and vertical force at Kew. Some analogous results were also given for Wilhelmshaven, Potsdam, and Parc St. Maur.

The present paper is entirely devoted to the connection between sunspot frequency and terrestrial magnetism. It deals with data from Milan (1836—1901), Greenwich (1841—96), Pawlowsk and Katharinenburg (1890—1900), Batavia (1887—98), and Mauritius (1875—90). It aims at ascertaining wherein the results in my previous paper are peculiar to the station or period (chiefly 1890—1900) dealt with.

It investigates what differences may exist between the sunspot connection on ordinary days and on magnetically quiet days, and what differences arise when one applies (1) to the mean of the differences between the absolutely highest and lowest daily readings, instead of to the range of the mean diurnal inequality. It also considers various measures of the magnetically disturbed character of the year, and their relation to sunspot frequency.

§ 2. The inquiry into the influence of the period selected on the values of a and b in (1) is based on the above-mentioned Milan and Greenwich results, due respectively to Signor Rajna and Mr. Ellis. In both cases, unfortunately, there is a want of strict homogeneity in the earlier data. The Greenwich data suggest a slight progressive increase in b/a during the last 60 years in the case both of declination and horizontal force; but this is not confirmed by the Milan results. The values, however, obtained from b/a in the case of the declination range at Milan from the two periods 1837—50 and 1854—67 are, the one 28 per cent. below, the other 12 per cent. above the value obtained by Rajna for the period 1836—94. In more recent years there is less apparent irregularity in the magnetic and sunspot relation. This

* 'Phil. Trans.,' A, vol. 202, p. 335.

suggests, of course, that the apparent considerable variations in the values of b/a just alluded to may be mainly due to observational imperfections, but uncertainty is not unlikely to remain on this point until the recurrence of a period of exceptionally high or low sunspot frequency.

§ 3. Table I gives some of the principal results obtained in the case of the range of the mean diurnal inequality for the year. The units are 1′ for angles, and 0·00001 C.G.S (or 1 γ) for force components.

Table I.

Place.	Data from—	Declination.			Horizontal force.			Vertical force.		
		a.	10^4b.	$10^4b/a$.	a.	10^3b.	$10^4b/a$.	a.	10^3b.	$10^4b/a$.
Pawlowsk	All days ..	5·74	400	70	20·7	211	102	8·1	265	326
,, ...	Quiet days	6·17	424	69	20·6	195	95	5·9	27	46
Katharinenburg.	All days ..	5·29	342	65	16·8	182	109	8·6	117	137
Kew	Quiet days	6·10	433	71	18·1	194	107	14·3	81	56
Batavia	All days ..	2·47	179	73	38·7	274	71	30·1	156	52
Mauritius	,, ..	4·06	164	40	15·0	96	64	11·9	69	58

If we exclude Mauritius, where several anomalous features present themselves, we notice a remarkable uniformity in the values of b/a for declination in Table I. The extraordinarily large differences between the "all" day and "quiet" day (Wild's *normal* day) results at Pawlowsk for vertical force presents itself in every month of the year. Pawlowsk is a station where magnetic disturbances are particularly prominent, and the vertical force there seems particularly sensitive to them.

§ 4. For Greenwich only mean monthly diurnal inequalities were available. Table II gives the mean of the 12 monthly values of

Table II.

Place.	Period.	Data from—	Declination.			Horizontal force.		
			a.	10^4b.	$10^4b/a$.	a.	10^3b.	$10^4b/a$.
Pawlowsk	1890—1900	All days....	6·81	446	66	22·8	243	107
,, ...	,,	Quiet days..	6·52	442	68	22·2	208	94
Katharinenburg	,,	All days....	6·18	355	58	19·2	195	101
Greenwich	1841—1896	,, ...	7·29	377	52	26·4	190	72
,, ...	1865—1896	,, ...	7·07	396	56	23·6	215	91
,, ...	1889—1896	,, ...	6·71	418	62	23·7	218	92
,, ...	,,	Quiet days..	6·36	415	65	25·0	213	85
Kew..........	1890—1900	,, ..	6·49	410	63	21·5	191	89

a and b, and the corresponding value of b/a for Greenwich and some other stations. Here, as in Table I, the data relate to the mean diurnal inequality. The units are the same as in Table I.

§ 5. For comparison with Table I, I give in Table III results applicable to the mean value for the year of the absolute daily ranges (taken from individual days irrespective of the hours of occurrence of the maximum and minimum). The units are as before:—

Table III.

Place.	Declination.			Horizontal force.			Vertical force.		
	a.	$10^4 b$.	$10^4 b/a$.	a.	$10^3 b$.	$10^4 b/a$.	a.	$10^3 b$.	$10^4 b/a$.
Pawlowsk	11 ·3	1130	100	45 ·2	636	141	17 ·6	520	295
Katharinenburg.	8 ·00	652	82	30 ·7	366	119	14 ·6	248	171
Mauritius	5 ·53	255	46	30 ·4	186	61	16 ·2	84	52

The large increase in the values of both a and b as compared to Table I will be noted. Except at Mauritius, the values of b/a for declination and horizontal force are considerably greater in Table III than in Table I. There seems, in fact, a general tendency for b/a to increase as we pass from a quantity, such as the range of a diurnal inequality, which is comparatively independent of disturbances, to a quantity such as the mean absolute daily range, which is largely dependent on disturbances. Formula (1) becomes, however, less and less strictly applicable, the more disturbed the magnetic quantity to which it is applied. When we consider quantities such as the mean of the 12 monthly ranges (maximum and minimum for the month), or the annual range (maximum and minimum for the year), we find large differences between observed values and those calculated from (1). In all the stations considered, 1893, though a year of absolute sunspot maximum, was much less disturbed than 1892. At Pawlowsk and Katharinenburg 1893 might fairly be termed a quiet year, while 1892 and 1894 were largely and persistently disturbed.

In the case of ranges from mean diurnal inequalities for the year, the agreement between observed and calculated values is about equally good at Pawlowsk, Katharinenburg, Batavia, and Kew. In the case of declination, the mean difference between observed and calculated values is about 4 per cent. of the mean value of the range during the period dealt with. On the whole, the agreement is distinctly less good in the case of vertical force than in the case of declination, inclination or horizontal force.

When extracting data from the earlier of the two papers by Mr. Ellis* already mentioned, I found that he had there advanced evidence—though he seems hardly to have considered it conclusive—that the difference between the Greenwich declination and horizontal force ranges in years of many and few sunspots was not the same in different seasons of the year. Converted into exact mathematical language, this would imply the variability of b throughout the year. If I had been aware at the time of Mr. Ellis's remarks on this point I should have referred to them in my preliminary note† on this subject.

"The Optical Properties of Vitreous Silica." By J. W. GIFFORD and W. A. SHENSTONE, F.R.S. Received January 12,—Read March 3, 1904.

The properties of vitreous silica suggest that it is not unlikely to play an important part in optical work. Its composition is definite, that is to say, it is not liable to those minute variations which make it impossible, we believe, to produce with certainty two meltings of glass which exhibit no sensible difference in their optical properties when tested by a first-rate spectrometer. Hardly any corrosive fumes, except those of fluorine and hydrogen fluoride, attack silica, and it is indifferent to most ordinary solvents. It is as transparent to ultra-violet radiations as quartz, but is not doubly refracting like that substance. And though it is a little difficult to prepare vitreous silica in large masses, this difficulty can be surmounted, and the supply of the substance is not limited like that of fluorite. In short, vitreous silica places at our disposal a really standard glass. The refractive index of the new glass is low, it approaches that of fluorite. Its dispersive power is sensibly greater than that of quartz.

The measurements given in this paper were made with a prism having faces 41 mm. high by 32 mm. wide, and angles of 60° approximately. The mass of silica from which this prism was cut was made under the supervision of one of us in conjunction with Mr. H. G. Lacell, to whom our thanks are due. As it was our object to produce a standard substance for optical work, no care was spared at this stage. In making the mass of silica the spectroscopic traces of lithium and the traces of sodium which occur in quartz were burnt out as completely as possible in the oxy-gas flame. The prism itself was built up from many hundreds of fine rods of vitreous silica, prepared specially for this purpose by a process which has been

* 'Phil. Trans.,' for 1880.

† 'Roy. Soc. Proc.,' vol. 71, p. 221.